09:01:52 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 08/02/95

Active

Project #: G-35-X08 Cost share #: G-35-339 Rev #: 6
Center # : 10/24-6-R7793-0A0 Center shr #: 10/22-1-F7793-0A0 OCA file #:
Work type : RES
Contract#: OPP-9218952 Mod #: OPAS Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : Y CFDA: 47.050
Main project #: PE #: N/A

Project unit: E & A SCI Unit code: 02.010.140
Project director(s):
DAVIS D D E & A SCI (404)894-3895
EISELE F L EOEML (404)-

Sponsor/division names: NATL SCIENCE FOUNDATION / GENERAL
Sponsor/division codes: 107 / 000

Award period: 930301 to 960831 (performance) 961130 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	292,777.00
Funded	0.00	292,777.00
Cost sharing amount		82,827.00

Does subcontracting plan apply ?: N

Title: AN EXPERIMENTAL STUDY OF TROPOSPHERIC SULFUR CHEMISTRY IN ANTARCTICA

PROJECT ADMINISTRATION DATA

OCA contact: Jacquelyn L. Bendall 894-4820

Sponsor technical contact

BERNHARD LETTAU
(703)306-1033

NATIONAL SCIENCE FOUNDATION
4201 WILSON BLVD.
ARLINGTON, VA 22230

Sponsor issuing office

PAMELA A. HAWKINS
(703)306-1213

NATIONAL SCIENCE FOUNDATION
4201 WILSON BLVD.
ARLINGTON, VA 22230

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : N/A NSF supplemental sheet
Equipment title vests with: Sponsor GIT X

Administrative comments -
ISSUED TO EXTEND PROJECT TERMINATION DATE TO AUGUST 31, 1996 WITH THE FINAL REPORT DUE NOVEMBER 30, 1996.

/

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 02/20/97

Project No. G-35-X08 Center No. 10/24-6-R7793-0A0

Project Director DAVIS D D School/Lab E & A SCI

Sponsor NATL SCIENCE FOUNDATION/GENERAL

Contract/Grant No. OPP-9218952 Contract Entity GTRC

Prime Contract No.

Title AN EXPERIMENTAL STUDY OF TROPOSPHERIC SULFUR CHEMISTRY IN ANTARCTICA

Effective Completion Date 960831 (Performance) 961130 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	N	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments
LETTER OF CREDIT APPLIES. 98A SATISFIES PATENT REPORT.

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other	N
	N

6-35-X08
/

Georgia Tech

School of Earth and Atmospheric Sciences

Georgia Institute of Technology
Atlanta, Georgia 30332-0340
USA
404•894•3893
404•853•0232 (FAX)

November 29, 1993

Dr. Bernhard Lettau
National Science Foundation
-Office of Polar Programs-

1800 G Street NW
Washington, DC 20550

Dear Dr. Lettau:

Enclosed please find my Annual Progress Report for Year 01 of NSF project: OPP-9218952, entitled: "An Experimental Study of Tropospheric Sulfur Chemistry in Antarctica."

Sincerely,

H. Berresheim, SRS

NSF Grant No. OPP-9218952, Office of Polar Programs

AN EXPERIMENTAL STUDY OF TROPOSPHERIC SULFUR CHEMISTRY IN ANTARCTICA

Progress Report for Year 01 (03/01/93 - 02/28/94)

PI: Dr. Harald Berresheim, Georgia Institute of Technology, School of Earth and Atmospheric Sciences, Atlanta, GA 30332,
Phone: (404) 894-3824

Co-PI: Dr. Fred L. Eisele, Georgia Tech Research Institute/National Center for Atmospheric Research, Boulder, CO 30307,
Phone: (303) 491-1483

Present Status of the Project

As of the date of this report, the major field experiment planned for Palmer Station in Year 01 has not yet been executed. It will be conducted over the period of January 1 - March 5, 1994. However, significant progress has been made in preparing this experiment, both through instrumental testing, new method development, and modelling studies pertaining to the atmospheric sulfur cycle over remote oceanic regions such as the Antarctic coastal Peninsula. As explained in detail below, the extent of the program has also grown beyond its original proposal outline.

1. The mass spectrometric detection technique for atmospheric OH developed by Dr. Eisele's group has been successfully tested (for a second time) in a broad-based intercomparison/photochemistry experiment during the summer of 1993 near Boulder, Colorado. Significant improvements have been made to the in-field OH calibration system of this instrument which now make it possible to monitor OH even at extremely low concentrations at night (down to 10^4 molec/cm^3) and with a precision of about 30% at typical daytime levels expected in the Antarctic summer troposphere.

2. In collaboration with Prof. E. Saltzman (Univ. of Miami) and Dr. A. Torres (NASA/Wallops Flight Facility) three of the participating team members have been intensively trained on continuous real-time techniques for SO_2 and NO detection, respectively. The respective detection limits are 7 pptv and 1 pptv, and, thus, both techniques are highly suitable for our experiment at Palmer Station. The corresponding instruments have already been shipped. In addition, another team member has been trained to set up and operate an acoustic sounder instrument at Palmer to continuously monitor boundary layer height. This instrument has been developed and is loaned to us by Dr. Bill Neff (NOAA) who will be responsible for its data evaluation after our return from Palmer. Intensive contacts have also been established with Prof. C. Stearns (Univ. of Wisconsin) and Biospherical Instruments for routine acquisition of meteorological and UV spectral data during our stay at Palmer.

3. In Year 01 we have successfully developed a new mass spectrometric

technique to measure dimethylsulfone ($DMSO_2$), a key end product of dimethylsulfide (DMS) oxidation. The detection is in real-time at low pptv levels. A possible interference by dimethyl disulfide (DMDS) has been found to be negligible. The major logistical advantage of this technique is that it is very similar to ourpreviously established detection method for dimethylsulfoxide (DMSO), the precursor of $DMSO_2$. Thus, both compounds can now be monitored quasi-simultaneously and in real-time.

4. New kinetic evidence and a mechanistic model of DMS chemistry over remote oceans developed in collaboration with Profs. P. Wine and D. Davis (Georgia Tech/EAS) suggest that DMSO and $DMSO_2$ may play a much more important role as DMS oxidation products than previously thought, especially in high latitudes. Therefore, our measurements of the relative levels of $DMSO_2$, SO_2, and sulfuric acid (the latter is predominantly responsible for forming cloud condensation nuclei, CCN) will further elucidate our understanding of atmospheric DMS chemistry and of the cloud-and-climate influencing capacity of biogenic DMS emissions in the Antarctic troposphere.

Plans for Year 02

Due to the relative timing of the field portions of the present project, most of the data evaluation will shift into the year succeeding Year 01 and Year 02, respectively. The second year of the project will in part be dedicated to data evaluation from Year 01 and model studies in close collaboration with Drs. D. Davis, W. Chameides, A. Torres, and W. Neff. Many important ancillary parameters, e.g., meteorological data, will have to be incorporated into the model calculations. These data will become available later during Year 02. The planned January/February 1994 field experiment will be even more comprehensive in terms of measurement effort and data modelling than the Year 01 experiment. Therefore, we intend to apply for additional funding for data evaluation in 1994-95 and will submit a corresponding 1-year proposal to OPP by the deadline of June 30, 1994. We also intend to involve other groups into our data evaluation, such as Prof. Mayewski's group (Univ. of New Hampshire) who have a potential interest in using the data to better understand the sulfur record in Antarctic ice cores in relation to paleoclimatic changes.

Further method development and testing is planned for 1994. In particular, we plan to test a real-time mass spectrometric technique for measuring SO_2 in the context of an intercomparison experiment at the Univ. of Delaware in September, 1994, which, if successful, could be implemented into the already existing method for OH, MSA, and H_2SO_4 detection in future field measurements.

Publications in Year 01 Acknowledging OPP:

1. Berresheim, H., D.D. Davis, and P.H. Wine, Sulfur Compounds in the Atmosphere, in: Composition, Chemistry, and Climate of the Atmosphere, Chapter 11, H.B. Singh (ed.), Van Nostrand Reinhold Publishers, in press (1993).

2. Berresheim, H., D.J. Tanner, and F.L. Eisele, Method for Real-Time Detection of Dimethyl Sulfone in Ambient Air, Anal. Chem., 65, 3168-3170 (1993).

G-35-X08
#2

OMB Number 345-0058

NATIONAL SCIENCE FOUNDATION
4201 Wilson Blvd.,
Arlington, VA 22230

BULK RATE
POSTAGE & FEES PAID
National Science Foundation
Permit No. G-69

PI/PD Name and Address

Douglas D. Davis
School of Earth and Atmospheric Sciences
GA Tech Res Corp - GIT
Atlanta GA 30332-0340

NATIONAL SCIENCE FOUNDATION
FINAL PROJECT REPORT

PART I - PROJECT IDENTIFICATION INFORMATION

1. Program Official/Org.	Bernhard Lettau - OPP
2. Program Name	POLAR OCEAN SCIENCES
3. Award Dates (MM/YY)	From: 03/93 To: 08/96
4. Institution and Address	GA Tech Res Corp - GIT Administration Building Atlanta GA 30332
5. Award Number	9218952
6. Project Title	An Experimental Study of Tropospheric Sulfur Chemistry in Antarctica

** You are encouraged to submit your Final Project Report electronically **
** through the NSF FastLane home page (www.fastlane.nsf.gov). **

This Packet Contains
NSF Form 98A
And 1 Return Envelope

PART II SUMMARY OF COMPLETED PROJECT

In January and February 1994 the Sulfur Chemistry in the Antarctic Troposphere Experiment (SCATE) was conducted at Palmer Station (64°46'S 64°03'W), Antarctica. Major objectives of SCATE were: to obtain a comprehensive data base for modelling the atmospheric chemistry of DMS in high latitudes, 2. to study processes related to new particle nucleation and particle growth, 3. to contribute to a better understanding of the marine biogenic sulfur record in Antarctic ice cores with respect to past global climate change, 4. to provide a model data base for estimating the sensitivity of the present climate of Antarctica to anthropogenic/volcanic sulfur pollution. Species measured included the basic photochemical parameters NO, O_3, CO, H_2O, and solar UV as well as the centrally important hydroxyl radical, OH. Sulfur measurements included DMS (marine and air samples), DMSO, and $DMSO_2$, MSA(gas phase and particulate), H_2SO_4(g) and nss SO_4^{-2}, particle size/number distribution. Based on observations of these species/parameters , it now appears that local DMS levels are controlled both from local sources as well as patchy distant sources which are advected into the area. Of special significance is the presence of quasi permanent low pressure systems in the area which lead to the shallow convective pumping of considerable amounts of DMS into the mid/lower FT. These air parcels move out from the region of pumping, undergoing radiative cooling and the loss of most of their water, while DMS is slowly oxidized via OH addition rxs and to a lesser extent OH abstraction. Major addition products such as DMSO and $DMSO_2$ build up to reservoir levels with photochemistry acting to further convert DMSO into more stable oxidation products such as MSA and perhaps H_2SO_3. Any newly formed H_2SO_4 and MSA would appear to be removed relatively quickly due to nucleation or particle growth processes. For reasons not yet completely understood this lower FT air on a rather frequent basis subsides into the BL as blobs which result in sulfur being returned to the surface within a very short time span.

PART III- TECHNICAL INFORMATION: Project SCATE

Introduction: In January and February 1994 the Sulfur Chemistry in the Antarctic Troposphere Experiment (SCATE) was conducted at Palmer Station (64°46'S 64°03'W), Antarctica. This station is located just below the polar circle and is the smallest of the three year-round operating U.S. Antarctic stations. During these two months the frequency of overcast conditions and precipitation events (about 40-45 mm/month) is typically 5-7 days per week, and thus, quite unfavorable for conducting a photochemical study. On the other hand, the expected advantages of performing the experiment at Palmer Station, such as close proximity to the ocean and minimal anthropogenic emissions, was considered at the time of planning to outweigh the above cited photochemical and work space limitation.

The complement of species measured during SCATE included the basic photochemical parameters NO, O_3, CO, H_2O, and solar UV as well as the centrally important hydroxl radical, OH. Sulfur measurements included DMS (marine and air samples), DMSO, and $DMSO_2$, MSA(gas phase and particulate), H_2SO_4(g) and nss SO_4^{-2}, particle size/number distribution. Efforts to measure SO_2, using a new fluorescence technique, were unfortunately unsuccessful. These measurements were hampered by high blank variations and a number of technical problems which could only partially be solved in the field. A post-mission reevaluation of the data resulted in the decision to discard these data.

Because the SICIMS mass spec system was used to measure sulfur species as well as OH, thus involving the detection of both positive and negative ions, it was necessary to time-share this instrument. Thus, DMSO and $DMSO_2$ were measured early in the program, between 18-24 Jan, followed by measurements of MSA and H_2SO_4 between 4-25 Feb, and OH between 16-25 Feb.

Results: Shown in Table I are Palmer Station summary data for several different sulfur species. These results clearly indicate that large variability was observed in the levels of most species. The mean DMS flux estimated from sea water measurements is seen as 2.3 umol/m^2/d, and is somewhat on the low side relative to other reported DMS summertime fluxes. Again, however, at the time of sampling things appeared to be quite patchy and in addition there were periodic intense storms. This variability is also reflected in the DMS(air) data which reached highs of nearly 500 pptv in late Jan/earlier Feb; but more frequently had mixing ratios in the range of 50-200 pptv. As seen in Table 1, DMSO and $DMSO_2$ also show major variations in concentration levels with oscillations from median values being factors of 10 to 15. Quite significant here is the fact with the possible exception of Jan 19, the fluctuations in the mixing ratios of these two species was found to be quite independent of the level of solar activity, e.g., see Fig. 5. Note, some of the largest changes occur under dark conditions. A more detailed analysis of these data as shown in Figs. 6a and 6b show that all high values of DMSO and $DMSO_2$ are associated with the lowest equivalent potential temperature, Θ_e, and the lowest dew points, DP. Thus, these data strongly suggest that air is

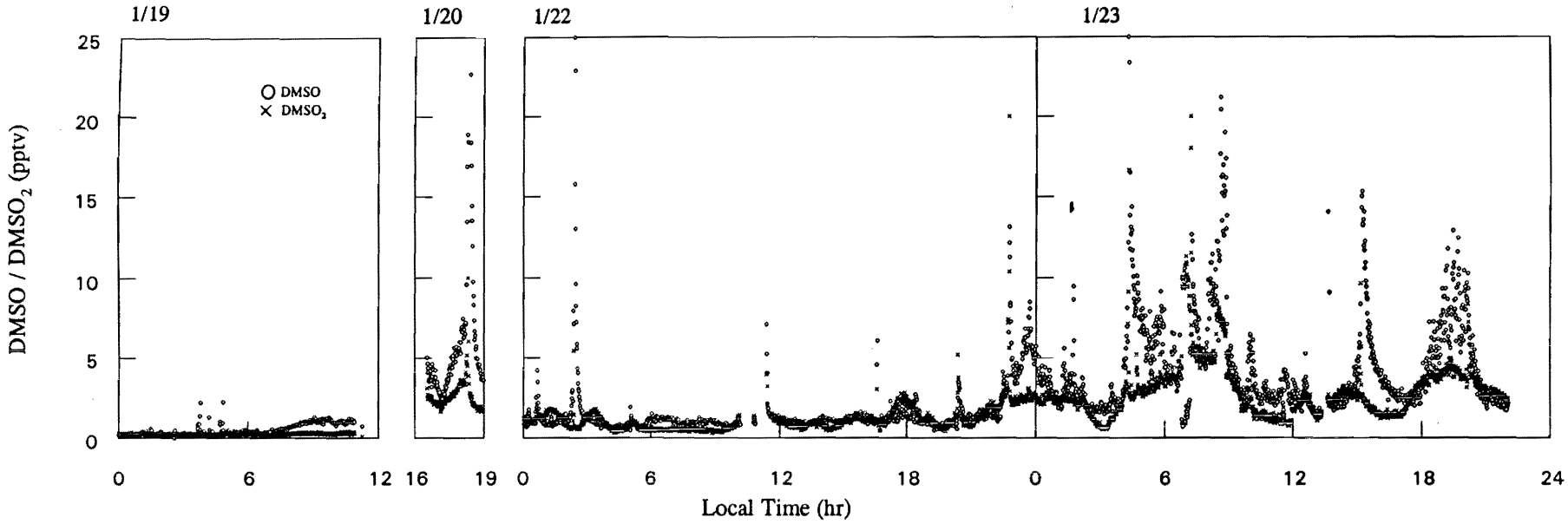

Figure 1. Time series of DMSO and $DMSO_2$ measurements at Palmer Station, Antarctica from 19-23 January, 1994.

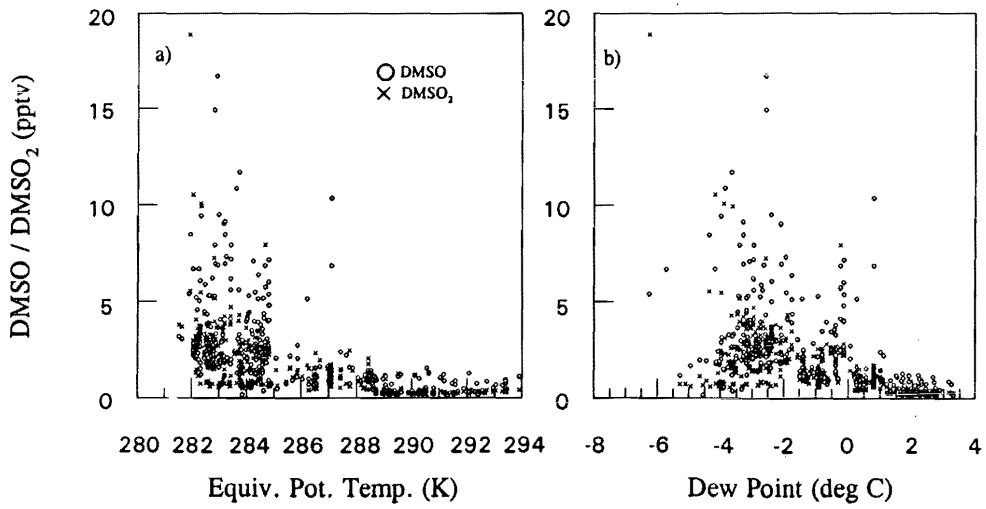

Figure 2. Scatterplots of DMSO and $DMSO_2$ vs. a) Equivalent Potential Temperature and b) Dew Point.

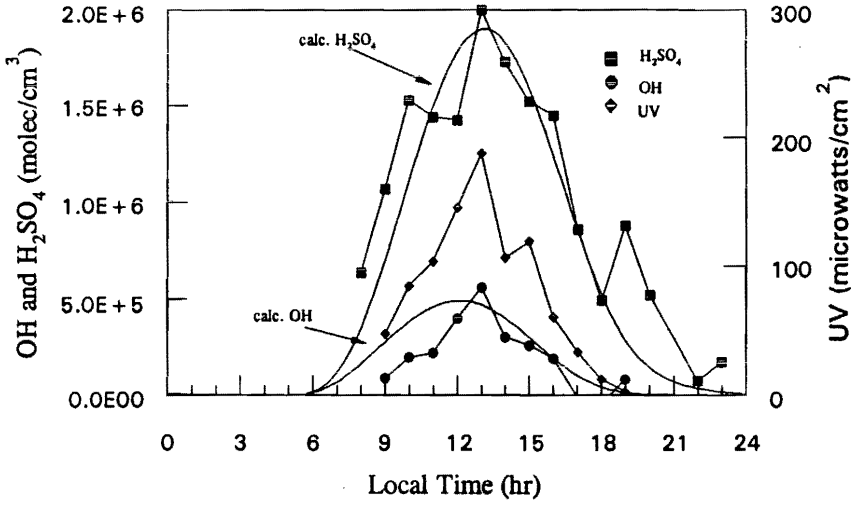

Figure 3. Diurnal profile of measured OH (circle), H_2SO_4 (square), and UV (diamond) at Palmer Station, Antarctica on 19 February, 1994. Smooth lines indicate model calculated OH and H_2SO_4 profiles.

Table 1. Statistical summary of Palmer field data.

	Units	Range	Median	Mean
DMS (air)	pptv	6-595	94	119
DMS (sea)	nM	0.7-3.7	1.97	1.86
DMS Flux	μmol/m^2/d	0.032-19.21	1.14	2.31
DMSO	pptv	0-25	1.5	2.3
$DMSO_2$	pptv	0.2-11	1.3	1.7
MSA(p)	nmol/m^3	0.15-6.25	1.28	1.66
NSS	nmol/m^3	0.04-6.88	1.88	2.48

Table 2. Averages filtered by equivalent potential temperature.

Eq. Pot. Temp.	< 284K	> 288K	Ratio (</>)
NSS (nmol/m^3)	5.55	1.16	4.80
MSA (nmol/m^3)	3.18	0.45	7.05
MSA(g)[a]	3.40E+05	6.45E+05	0.53
H_2SO_4(g)[a]	5.51E+05	1.16E+06	0.47
DMSO (pptv)	3.25	0.62	5.21
$DMSO_2$ (pptv)	2.97	0.44	6.72

a-units are molecules/cm^3

subsiding from the lower free troposphere in non-uniform blobs, and further raises the question as to what fraction of marine BL released DMS is being transported into the free troposphere and oxidized there.

By contrast, as shown in Fig. 7 the concentration levels of H_2SO_4, and to a rather large extent MSA, did track with solar activity. However, in this case the removal of both of these species was estimated to be less than 2 hrs. Since both species are stable with respect to attack by OH and are not themselves readily photolyzed, the loss process is quite clearly physical removal. Based on measured total particulate surface area, the assumption of a sticking coefficient of ~.5 for H_2SO_4 gave a rather good fit to the observed profile.

The formation of H_2SO_4 is yet another interesting aspect of the Palmer data in that it was found that oxidation of DMS within the BL to give SO_2, via the OH abstraction channel, could explain less than 3% of the required H_2SO_4 formation rate, based on the $OH+SO_2+M$ rx. Modelling simulations of these BL conditions suggests that either SO_2 was being entrained from the FT (the required levels in the FT were estimated to range from 60-170 pptv) or that some fraction of the OH abstraction channel (e.g., .15 to .4) was going to SO_3 through some intermediate, which itself was then converted with high efficiency to H_2SO_4 (e.g., see Fig. 4). In the absence of SO_2 observations both explanations either independently or in combination appear plausible.

As noted above, on the one day early during the field campaign in which it appears that downwelling from the FT was minimal, Jan 19, the DMSO and $DMSO_2$ do appear to track solar activity. If the assumption is made that indeed this was the case, a more detailed modelling analysis of this one day leads to the following tentative conclusions: 1) under typical BL conditions the oxidation of DMS can not explain the observed levels of DMSO. 2) The observed diurnal profile of DMSO on the 19th is consistent with a rate of formation from DMS oxidation that agrees with current OH addition kinetic data but with a loss rate that is nearly seven times faster than that predicted for the OH+DMSO rx [Hynes et al., 1996]. This again suggests that the loss of DMSO as well as probably $DMSO_2$ is not controlled by photochemistry in the BL, but rather, physical loss on particles or loss to ocean/land/ice surfaces. Estimated lifetimes range from 2 to 3 hrs. Given the total particle surface area at that time, a sticking coefficient of 0.2 would be required to explain our results. This value is quite close to that recently reported by Kobe et al., [1994].

Discussion: As noted above, one of the interesting questions that the above data raises is: what fraction of the BL released DMS is being oxidized in the FT? To explore this question

we have examined all data collected at Palmer in terms of Θ_e such that data were binned based on when air was most likely inflowing from the FT (i.e., $\Theta_e < 284K$) versus air that was more characteristic of the BL ($\Theta_e > 288K$). These results are shown in Table 2. What is apparent from these tabulated data is that species that most likely would tend to have short lifetimes even in the absence of high particle surface areas, e.g., due to nucleation or particle growth (e.g., $H_2SO_4(g)$ and MSA(g)), show no increase and perhaps even a decrease; whereas, those that might be expected to have longer lifetimes (i.e., DMSO, DMSO2, MSA(p), and NSS(p)) show increases of factors of 5 to 7. Thus, if one were to make the simplest of assumptions that the lifetimes of the latter group of species is ~6 times greater in the FT, it would suggest that as much as half the DMS might have been oxidized in the FT.

In summary, it now appears that local DMS levels are controlled both from local sources as well as patchy distant sources which are advected into the area. The presence of quasi permanent low pressure systems in the area lead to the pumping of considerable amounts of DMS into the mid/lower FT via shallow convection. This air parcel moves out from the region of pumping, undergoing radiative cooling and the loss of most of its water, while DMS is slowly oxidized via OH addition rxs and to a lesser extent OH abstraction. The major addition products DMSO and $DMSO_2$ build up to reservoir levels with photochemistry acting to further convert DMSO into more stable oxidation products such as MSA and perhaps H_2SO_3. Any newly formed H_2SO_4 and MSA would appear to be removed relatively quickly due to nucleation or particle growth processes. For reasons not yet completely understood this lower FT air on a rather frequent basis subsides into the BL in a non-uniform manner as blobs which results in the sulfur being returned to the surface within a very short time span.

Although still speculative in many of its details the above picture is considerably different (for this region) than what has previously been thought to define DMS chemistry. It clearly emphasizes the important role that atmospheric dynamics can play in defining DMS product distributions, and it also clearly points out how important fast-time-resolution measurements are to understanding the coupling between chemistry and dynamics.

Publications Resulting from Award

H. Berresheim, D. J. Tanner, and F. L. Eisele, Method for real-time detection of dimethyl sulfone in ambient air, *Analytical Chemistry*, *65*, 3168, 1993.

H. Berresheim, F. L. Eisele, D. J. Tanner, and A. Jefferson, Atmospheric sulfur and hydroxyl radical measurements at Palmer Station, *Antarctic Journal of the U.S.-Review 1994*, *XXIX*, 312, 1995.

H. Berresheim and F. L. Eisele, Sulfur chemistry in the Antarctic Troposphere Experiment: An overview of project SCATE, submitted to *Journal of Geophysical Research.*

H. Berresheim, J. W. Huey, R. P. Thorn, F. L. Eisele, D. J. Tanner, and A. Jefferson, Measurements of dimethylsulfide, dimethylsulfoxide, dimethylsulfone, aerosol sulfur ions, and cloud condensation nuclei at Palmer Station, Antarctica, submitted to *Journal of Geophysical Research.*

A. Jefferson, D. J. Tanner, F. L. Eisele, and H. Berresheim, Sources and sinks of H_2SO_4 in the remote Antarctic marine boundary layer, submitted to *Journal of Geophysical Research.*

A. Jefferson, D. J. Tanner, F. L. Eisele, J. W. Huey, D. D. Davis, C. Crawford, G. Chen, A. Torres, and H. Berresheim, OH Oxidation Chemistry and MSA in the coastal Antarctic boundary layer, submitted to *Journal of Geophysical Research.*

D. D. Davis, G. Chen, P. Kasibhatla, H. Berresheim, and F. L. Eisele, DMS oxidation chemistry in the Antarctic marine boundary layer I: Comparison of modelling results with field observations for DMSO(g) and $DMSO_2$(g), In preparation, *Journal of Geophysical Research.*

D. D. Davis, G. Chen, P. Kasibhatla, H. Berresheim, and F. L. Eisele, DMS oxidation chemistry in the Antarctic marine boundary layer II: Comparison of modelling results with field observations for H2SO4(g) and MSA(g), In preparation, *Journal of Geophysical Research.*

Presentations from Spring 1996 AGU Meeting special session: Antarctic and Sub-Antarctic Tropospheric Chemistry: D. Davis and F. Eisele, Chairs

1) The sulfur chemistry in the Antarctic troposphere experiment: An overview of project SCATE: H. Berresheim, F. L. Eisele, and D. D. Davis (invited).
2) Hydroxyl radical concentrations in a remote marine environment: F. L. Eisele, D. J. Tanner, A. Jefferson, R. L. Mauldin, D. D. Davis, and H. Berresheim.
3) Measurements of DMS, DMSO, $DMSO_2$, aerosol ions, and cloud condensation nuclei at Palmer Station, Antarctica: H. Berresheim, F. L. Eisele, D. J. Tanner, A. Jefferson, J.) W. Huey, R. P. Thorn, A. L. Torres, W. D. Neff, T. P. deFelice, and V. K. Saxena 4)
4) Sulfate balance in the remote marine boundary layer: A. Jefferson, D. J. Tanner, F. L. Eisele, and H. Berresheim.
5) A comparison of model evaluated and measured H_2SO_4 profiles as observed during project SCATE: G. Chen, D. D. Davis, F. L. Eisele, D. J. Tanner, A. Jefferson, and H. Berresheim.
6) A comparison of model evaluated and measured DMSO profiles as observed during project SCATE: D. Davis, G. Chen, F. Eisele, D. Tanner, A. Jefferson, and H. Berresheim.

PART IV -- FINAL PROJECT REPORT -- SUMMARY DATA ON PROJECT PERSONNEL

(To be submitted to cognizant Program Officer upon completion of project)

The data requested below are important for the development of a statistical profile on the personnel supported by Federal grants. The information on this part is solicited in resonse to Public Law 99-383 and 42 USC 1885C. All information provided will be treated as confidential and will be safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a single copy of this part with each final project report. However, submission of the requested information is not mandatory and is not a precondition of future award(s). Check the "Decline to Provide Information" box below if you do not wish to provide the nformation.

Please enter the numbers of individuals supported under this grant.
Do not enter information for individuals working less than 40 hours in any calendar year.

	Senior Staff		Post-Doctorals		Graduate Students		Under-Graduates		Other Participants[1]	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
A. Total, U.S. Citizens	3			1	1				3	
B. Total, Permanent Residents										
U.S. Citizens or Permanent Residents[2]:										
American Indian or Alaskan Native										
Asian.....										
Black, Not of Hispanic Origin.....										
Hispanic										
Pacific Islander										
White, Not of Hispanic Origin										
C. Total, Other Non-U.S. Citizens										
Specify Country 1.										
2.										
3.										
D. Total, All participants (A + B + C)	3			1	1				3	
Disabled[3]										

☐ Decline to Provide Information: Check box if you do not wish to provide this information (you are still required to return this page along with Parts I-III).

[1] Category includes, for example, college and precollege teachers, conference and workshop participants.

[2] Use the category that best describes the ethnic/racial status fo all U.S. Citizens and Non-citizens with Permanent Residency. *(If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)*

[3] A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment. *(Disabled individuals also should be counted under the appropriate ethnic/racial group unless they are classified as "Other Non-U.S. Citizens.")*

AMERICAN INDIAN OR ALASKAN NATIVE: A person having origins in any of the original peoples of North America and who maintains cultural identification through tribal affiliation or community recognition.

ASIAN: A person having origins in any of the original peoples of East Asia, Southeast Asia or the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

BLACK, NOT OF HISPANIC ORIGIN: A person having origins in any of the black racial groups of Africa.

HISPANIC: A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

PACIFIC ISLANDER: A person having origins in any of the original peoples of Hawaii; the U.S. Pacific territories of Guam, American Samoa, and the Northern Marinas; the U.S. Trust Territory of Palau; the islands of Micronesia and Melanesia; or the Philippines.

WHITE, NOT OF HISPANIC ORIGIN: A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.